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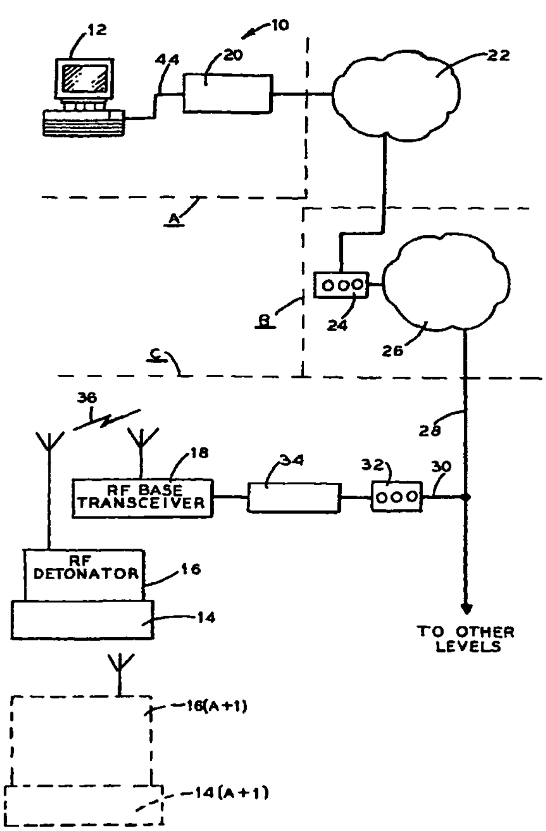
(54) Title: REMOTE WIRELESS DETONATOR SYSTEM



(57) Abstract: A wireless detonator system wherein a blast initiation signal emanating from a programmable controller (12) is broadcast to individual, remote programmable detonators (16) associated with specific explosive charges (14). The controller (18) communicates with a programmable RF base transceiver. Upon interpreting the blast initiation signal, the RF base transceiver broadcasts instructions to the detonators (14). By assigning a single sacrificial detonator to a single charge, a timed blast sequence may be created without the need for time consuming and expensive hand wiring of the charges.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

REMOTE WIRELESS DETONATOR SYSTEM

TECHNICAL FIELD

The instant invention relates to explosive detonator systems in general, and more particularly, to remotely activated detonators.

BACKGROUND ART

Explosives have been a necessary evil in the mining, demolition, quarrying and construction industries for centuries. Over the years, explosives technology has advanced arm-in-arm with safety considerations. The current state of the art generally consists of, in simplified fashion, a detonator, fuse, primer, and explosive. The detonator is usually energized via a hardwired electrical signal. By activating the detonator, the fuse is blown which sets off the primer. As the primer ignites, the charge subsequently explodes. For safety and efficiency reasons, the long daisy chain of firing components are strung together to (1) ensure no inadvertent firing and (2) affirmatively place and sequentially time the explosives for full effect.

Hardwired systems suffer from the need to tie numerous detonators together and connect the entire array to a remote initiator site. It is often difficult, labor intensive, expensive and time consuming to run long lengths of electrical wires from the blast site to the remotely situated initiation site. This is particularly true in underground mining applications using sequential blast patterns.

U.S. patent 5,159,149 to Marsden discloses a remote detonator system employing untethered radio frequency (RF) transmitters and receivers. Each detonator must be physically

coupled and uncoupled with a combined charging energy storage means and a programmable delay time means prior to shot initiation.

Canadian patent 1,309,299 to Beattie et al., discloses a wireless system including detonation means capable of receiving RF signals from a remote source hardwired to a fuse via connecting wires.

Canadian patent 1,298,899 to Beattie et al., discloses a dual detonation system employing RF and a steerable laser beam.

Wired designs include U.S. patent 5,295,438 to Hill et al. and U.S. patent 5,520,114 to Guimard et al. The former patent discloses a transportable programming tool and a control loop. Each detonator is affixed to a split core which is hooked to the loop. The latter patent discloses a feedback programming unit and an integrated electronic delay detonator.

Current commercially available detonation systems still ultimately require physically connecting wires to each detonator regardless of the mode of initiation.

The purpose of the present invention is to provide a remote wireless untethered blast initiation system. The need for such a system comes from a greater requirement to automate the complete mining process. A key part of the underground hard rock mining process is blasting. In order to automate blasting, a technique is needed to allow for the wireless initiation of a blast. Wiring a blast is a labor intensive manual process requiring a person to physically connect wires to each detonator. As well, many different time delays are required for the blast. Since development blasts can have a blast pattern containing 80 or more detonators, the possibility

for human error is high. These errors occur in the placement of a detonator with the wrong timing in a hole as designated by the mine engineers' blast design or designed by the development blaster. Incorrect placement and timing of the blast pattern creates poor break, bootlegs, loose rock, varying muck size and damage to the opening. This in turn creates higher mining costs.

The present invention allows data from a computerized blasting design program to be transferred directly to the detonators and the machine installing them. This reduces error and allows for a machine to automatically install the detonators. The elimination of wires greatly reduces the complexity of the automated machine required to install the detonators. The elimination of wires or other tethers such as shock tubes also eliminates the chance of the tethers being cut by the blast before the initiation signal can propagate to the other detonators. This creates a poor blast i.e. oversize chunks, poor perimeter contour and bootlegs. All of the factors create additional worker hazards and therefore cost. Efficiency and safety of the process is also improved since the blast design data is immediately available to the blast operator and is transferred by computer file instead of being read and acted upon by a person.

Conventional detonators come with preset times, creating the need to stock many different detonators, each with individual time delays. The present system allows one detonator to be stocked and allows for much finer control of the blast by allowing a higher resolution and greater number of delay times. The detonators may be timed in 1 millisecond (ms) increments up to 10,000 ms, giving total timing control. These times are determined by measuring rock properties. Matching

the timing to the rock properties gives consistent fragmentation, which is required in automated mining.

SUMMARY OF THE INVENTION

Accordingly, there is provided a wireless detonator system that is adapted to initiate a timed sequential blast pattern by direct wireless connection to each individual detonator.

A remote central processing unit (CPU) programmed with detonator programming software communicates to an RF base transceiver. The transceiver communicates to at least one dedicated RF detonator affixed to an individual charge via a RF signal. The detonator interprets the signal and fires off an internal fuse directly setting off the associated charge.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an overall schematic diagram of an embodiment of the invention.

Figure 2 is a schematic diagram of an embodiment of the invention.

Figure 3 is a schematic diagram of an embodiment of the invention.

Figure 4 is a schematic diagram of an embodiment of the invention.

PREFERRED EMBODIMENT OF THE INVENTION

Figure 1 depicts a schematic representation of the remote detonating system 10. A programmable controller 12, preferably a personal computer, ultimately communicates via a

wireless RF signal link with one or more discrete explosive charges 14 (A+1) (A equaling -1, 0, 1, 2, 3, etc.).

Each explosive charge 14 (A+1) includes its own affixed and dedicated micro RF detonator 16(A+1). (For non-limiting simplicity, any reference to an individual component will include multiple iterations unless indicated to the contrary, i.e. 14 and 16)

By virtue of the controller's 12 software, once a firing program has been initiated, an RF trigger will target each individual detonator 16 according to a preselected sequentially timed firing pattern. By reducing or eliminating wired connections between the CPU 12 and the blast site, the difficulties posed by the prior art direct hardwired or wireless systems are reduced.

In the embodiment depicted, the inventors utilized Inco Limited's preexisting broadband CATV communications system connecting surface structures to underground mine locations. However, as will become apparent, any communication system bridging the controller 12 and the blast site may be used.

The system 10 includes the controller/computer 12 (preferably equipped with Microsoft® Windows® 95 or NT® (or later), and Inco Limited's proprietary Teleblast™ blast control software [copyrighted copies are available from Inco Limited]), a local RF base transceiver 18 and one or more remote RF remote detonators 16.

As briefly stated previously, Figure 1 demonstrates Inco Limited's underground communications system in an abbreviated fashion. The controller 12, which may be disposed above ground or in any remote secure location, is connected to a conventional serial to ethernet converter 20. The signal is

passed through a conventional network 22 to a first standard modem 24. The modem 24 in turn is connected to a broadband CATV interface 26 which is disposed (in Inco's case) at the surface in a mine head frame. The communications link is passed underground through a main broadband underground communications trunk system 28.

A branch line 30 off the trunk 28 is diverted to a second standard modem 32 which in turn communicates with a conventional ethernet to serial converter 34. The converter 34 in turn communicates with the RF base transceiver 18.

As one skilled in the art may appreciate, the means for transmitting a signal from the controller 12 to the RF base transceiver 18 can be as varied as desired depending on site considerations, available equipment, finances, state of the art communication technology, etc. It is within the realm of this invention that in above ground situations such as demolition, construction, quarrying, etc, the distance and communication system may be relatively short, line of sight, wireless and simple. In other situations, the communication system traversing the controller 12 and RF base transmittal 18 may be quite involved, sophisticated and greatly spaced. Whatever the situation, however, one skilled in the art is capable of causing the controller 12 to communicate with the RF base transceiver 18 using available technology.

In the embodiment shown, the controller 12 ultimately communicates with the RF base transceiver 18 using its serial communications port (COM1) via a RS-232 serial bus 44. The RF base transceiver 18 modulates the data stream coming from the controller 12 onto a radio signal 36. The signal 36 is received by each individual RF detonator 16 and demodulated to

provide intelligence to a detonator internal central processing unit (CPU) 38. (See Figure 3).

The instant system 10 allows for easy integration onto a conventional PC two-way network such as one typically installed in underground mines. The system 10 takes advantage of existing cable and network infrastructure already installed thereby reducing cost. The cost of installing dedicated wiring is eliminated. Security of communications is ensured by using a mathematical coding scheme, cyclic redundancy check ("CRC"), addressable detonators 16 and a dedicated blasting radio channel.

The system 10 unabashedly takes advantage of the ever increasing and amazing reductions in electronic component size and cost. The components making up the RF detonator 16 can be made so small and cheaply that they are literally expendable. By physically mating the RF detonator 16 to each specific charge 14, the safety and efficiency of explosive blasting is considerably ramped up.

In the present discussion, a particular manufacturer's components are referenced for convenience. However, it should be understood that comparable alternatives may be substituted for the particular identified components. What must be borne in mind that a remote safety-triggering signal is transmitted from a remote initiation site to a transceiver 18. The transceiver 18 in turn broadcasts a wireless signal to a distinct explosive charge 14. Each charge 14 includes its own stand-alone dedicated transceiver detonator 16. The detonator 16 interprets the signal from the transceiver 18 and, if conditions are appropriate, initiates the explosive sequence.

Turning to Figures 2 and 3, the controller 12 is shown connected to the RF base transceiver 18 (minus intermediate connections).

The controller 12 is programmed with the appropriate software and commands the system 10. The Teleblast blast control software:

a) computes the CRC for communication verification and integrity. This is a method for checking the accuracy of a digital transmission over a communications link. The computer 12 performs a calculation on the data and attaches the resulting CRC value to the communication data stream; the receiving CPU 38 performs the same calculation and compares its result to the original value in anticipation of a hand shake confirmation. If they do not match, a transmission error has occurred and the receiving computer requests retransmission of the data;

b) allows the operator to program a blast batch identification number, a detonator identification number and detonator (cap) delay time in milliseconds (0 to 10000) into each detonator 16; and

c) allows the operator to initiate a common fire command to start a countdown from each individual detonator delay setting for all detonators 16 within a blast batch.

In the non-limiting embodiment shown, the RF base transceiver 18 includes an Adcom® Telemetry µ-T™ micromodule 40 (Adcom Telemetry Inc., Boca Raton, Florida, USA), and a source of low voltage power, i.e. a battery 42.

According to the manufacturer, the module 40 incorporates a small programmable microprocessor or CPU 46 and transmitter/receiver 48 into a small package that eliminates a hand wired system. The system 10 incorporates the advantages of digital/analog telemetry and programmable logic functions provided by the module 40 so as to recognize and respond to the CRC, the blast batch identifier, the blasting cap identifier, communications verification, the blasting cap detonator, fire command, detonation delay times, cycle times and any safety/override commands generated by the controller 12 (collectively "the recognition protocols").

The recognition protocols are programmed into and recognized by the module 40 and the resultant instructions are transmitted via an antenna 50. According to the manufacturer, depending on the configuration selected, the signal may be broadcast up to about a mile (1.6 km) - line of sight. In an underground environment, conventional accommodations may have to be made to access signals blocked by rock, ore, coal, debris, etc.

The RF base transmitter 18 transmits its signal 36 to one or more RF detonators 16. The self-contained detonator 16 includes a slave Adcom Telemetry µ-T micromodule 50 comprising a programmable microprocessor 38 and a transmitter/receiver 54 that are identical to their counterparts in the module 40. Signals broadcast from the RF base transceiver 10 are received by an antenna 56.

The detonator CPU 38 receives intelligence containing radio signals consisting of the relevant recognition protocols.

The detonator 16 is powered by an energy source 58 such as a battery or a charged capacitor. The energy stored in these devices begins to discharge once the energy source 58 is affirmatively engaged. Dissipation occurs through the module 50 or through a relay switch 60 on the detonator 16. The capacity of the energy source allows for a 24 hour discharge time. This way, if for some reason the blast cannot be fired, the blast does not remain alive. It must be reprimed in order to fire.

The energy source 58 also powers the transmitter/receiver 54, the detonator CPU 38, the relay 60 and a fuse 64.

Upon recognition and acceptance of the fire command signal by the detonator microcontroller 38, the detonator 16 outputs a fire command to the relay 60. The relay 62 switches the stored energy from the energy source 58 to the fuse 64. As the fuse 64 blows, the primer is activated causing discharge 82 and the explosion of the dedicated charge 14.

By utilizing an array of appropriately timed independent RF detonators 16, a sequential blast pattern can be initiated without the need for a rat's nest of wires.

Once the detonators 16 are loaded in the desired blasting pattern, there is no further need to physically come into contact with the detonators 16 and their associated charges 14. Preferably, the detonators 16 are remotely programmed after installation by the broadcast of the relevant installation recognition protocols from the controller. Because each detonator 16 is essentially a stand alone, self-contained unit with its own learning capable CPU 38 and related

discharge components 60, 64, 58, any post installation contact is minimized thereby increasing safety and efficiency.

Figures 4 depicts a successful prototype detonator 84.

The Adcom module 50 includes an 8-pin input/output (I/O) connector 66.

A Triridge™ 2988 5 volt SPST relay 68 was, for the test, connected to pins 2 and 6 of the connector 66 with a jumper 80 between pins 6 and 8 to complete the power circuit. A 300 ohm ¼ watt resistor 70 and light emitting diode (LED) 72 were bridged across the pins and the relay 68.

A 9 volt battery 74 supplies energy to the prototype. (A capacitor 76 is shown as an optional alternative to the battery 74). The jumper 80 supplies the power to the RF detonator 16. A fuse 78 (a flashbulb may be substituted for effect) is blown by the relay 68. Upon receipt of a "fire" signal from an RF base transceiver 18, the detonator 16 compares the transmitted recognition protocols and, when satisfied, opens the relay 68, illuminates the LED 72 and blows the fuse 78 (flash bulb).

As mentioned previously, the present system 10 easily lends itself to disparate operations. For example, in the non-limiting mining application depicted in Figure 1, the controller may be located on the surface in an office A, Communication lines 44 (which may also be wireless and close or distant from the blast site) link the controller 12 through an existing network 12 to a mine head end location B on the surface. The communications stream continues underground C through the mine's existing main broadband trunk 28 where eventually it is routed to the RF base transceiver 18 on the

level where blasting is contemplated. The RF transceiver 18 is positioned to expeditiously communicate with the various arranged RF self-contained detonators 16. The existing communications infrastructure provides efficient two-way communications between the RF detonator 16 and the controller 12.

Other examples would place the controller 12 as a laptop in a shed or mobile vehicle. If controller-blast site distances allow, the wired link between the controller 12 and the RF base transceiver 18 may be replaced with a RF communications package.

While in accordance with the provisions of the statute, there are illustrated and described herein specific embodiments of the invention, those skilled in the art will understand that changes may be made in the form of the invention covered by the claims and that certain features of the invention may sometimes be used to advantage without a corresponding use of the other features.

CLAIMS:

1. A remote detonator system, the system comprising a controller, the controller communicating with a base transceiver, the controller adapted to generate an initiation signal, the base transceiver remotely communicating with at least one self-contained detonator, the detonator associated with a dedicated explosive charge, the base transmitter adapted to recognize and respond to the initiation signal and initiate and transmit a resultant signal to the detonator, and the detonator adapted to receive and interpret the resultant signal to energize its dedicated explosive charge.

2. The system according to claim 1 wherein the base transceiver includes a microcontroller, the microcontroller communicating with a transceiver, and a power supply for the base transceiver.

3. The system according to claim 2 wherein the base transceiver includes an antenna.

4. The system according to claim 1 wherein the detonator is a stand alone unit, the detonator including a second remote accessible microcontroller, the second microcontroller communicating with a second transceiver, the microcontroller communicating with a second power source, the second microcontroller communicating with a relay, and a fuse.

5. The system according to claim 4 wherein the detonator includes a second antenna.

6. The system according to claim 4 wherein the fuse is connected to the explosive charge.

7. The system according to claim 1 wherein the controller includes blast initiation programming having recognition protocols, the base transceiver and the detonator adapted to learn, recognize and respond to the recognition protocols.

8. The system according to claim 7 wherein the recognition protocols include a communications link, a blast batch identifier, a blasting cap identifier, a communications integrity verifier, a blasting cap delay instruction, and a fire command.

9. The system according to claim 1 including a broadband connection between the controller and the base transceiver.

10. The system according to claim 1 wherein the base transceiver includes means for accepting the initiation signal from the controller, and CPU means for interpreting the initiation signal and transmitting a resultant signal away from the base transceiver.

11. The system according to claim 1 wherein the detonator includes means for accepting the resultant signal, CPU means for learning and interpreting the resilient signal, blast initiation means responsive to the resultant signal, and the detonator affixed to the dedicated explosive charge.

12. The system according to claim 1 including a plurality of detonators.

13. The system according to claim 1 including a plurality of dedicated explosive charges, each dedicated explosive charge affixed to a matching dedicated detonator.

14. The system according to claim 1 including an RF base transceiver.

15. The system according to claim 1 including at least one RF detonator.

16. A method of remotely initiating explosive charges by remotely activating detonators, the method comprising:

a) sending a initiation signal to a base transceiver, the initiation signal including preselected safety and firing parameters,

b) causing the base transceiver to receive and interpret the initiation signal and, if appropriate, generate a resultant fire signal,

c) causing the resultant fire signal to be broadcast over a known area,

d) receiving the resultant firing signal with a self-contained, stand-alone detonator, the alone detonator adapted to interpret the resultant firing signal, and

e) causing the resultant firing signal, if appropriate, to initiate an explosive charge particularly dedicated and connected to the stand-alone detonator.

17. The method according to claim 14 including utilizing a plurality of detonators with associated explosive charges, and each detonator connected to a dedicated explosive charge.

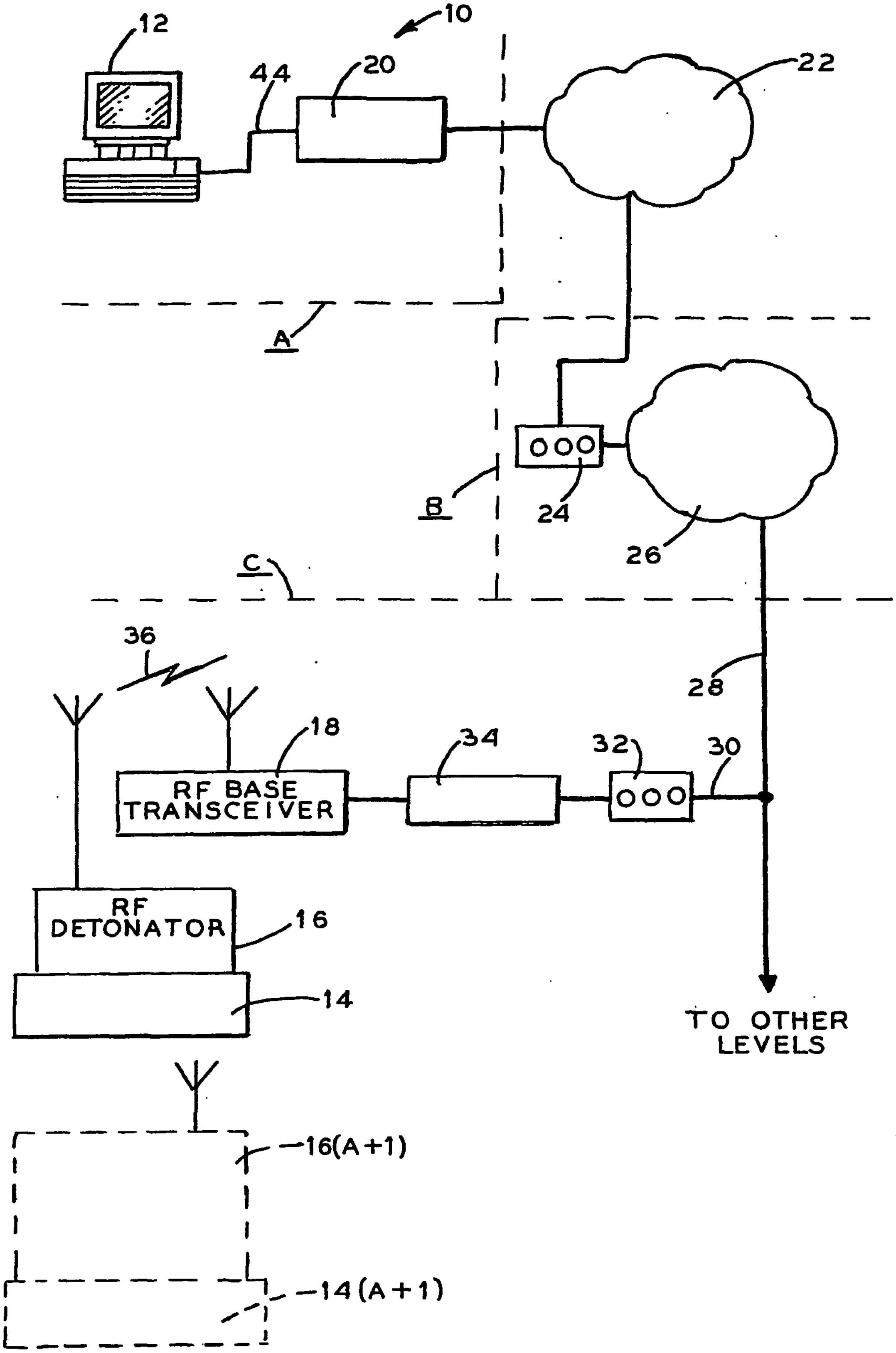
18. The method according to claim 16 including sending the initiation signal to the base transceiver via a broad band transmission.

19. The method according to claim 16 wherein the initiation signal includes recognition protocols, the base transceiver determining that the recognition protocols are appropriate, and transmitting the resultant fire signal to a detonator.

20. The method according to claim 16 wherein the firing signal is encoded in an RF signal transmitted from the base transceiver to a detonator.

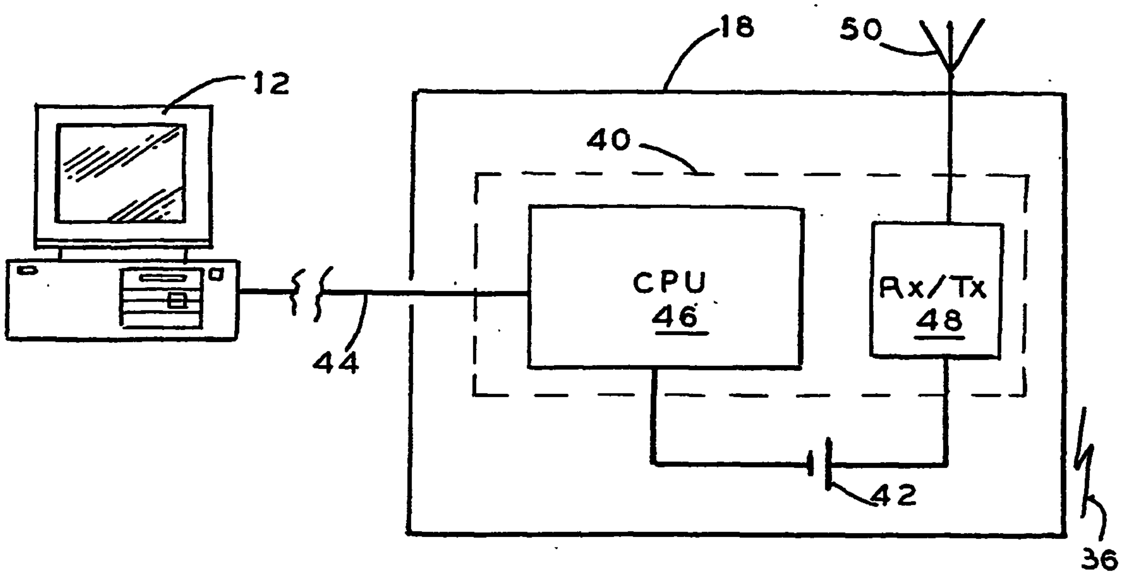
21. The method according to claim 16 including programming the detonator from a remote location.

FIG. 1



10
12
44
20
22
A
B
24
26
C
36
28
18
RF BASE TRANSCEIVER
34
32
30
RF DETONATOR
16
14
TO OTHER LEVELS
16(A+1)
14(A+1)

FIG.2



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18
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CPU
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Rx/Tx
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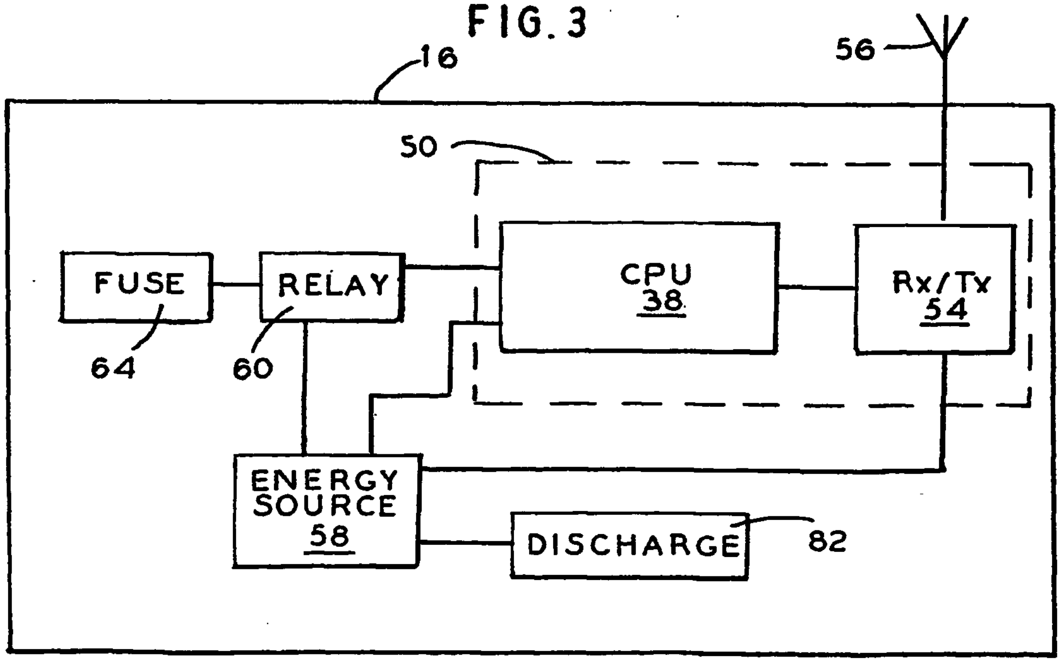
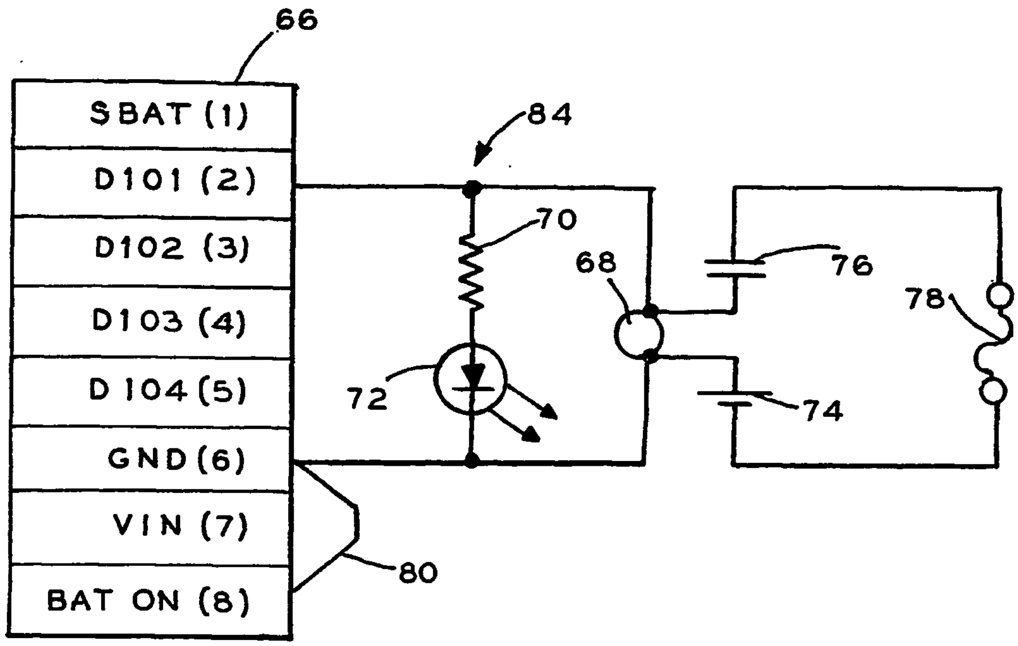
44
42
36

FIG.3



16
56
50
FUSE
RELAY
CPU
38
Rx/Tx
54
64
60
ENERGY SOURCE
58
DISCHARGE
82

FIG. 4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D102 (3)
D103 (4)
D104 (5)
GND (6)
VIN (7)
BAT ON (8)
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74
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INTERNATIONAL SEARCH REPORT

Inte   nal Application No
PCT/CA 00/01369

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F42D1/05

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F42D F42C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 99 24776 A (ROCKTEK LTD ;WRIGHT KEITH (AU); GAVRILOVIC MIKE (US)) 20 May 1999 (1999-05-20) page 8, line 1 -page 9, line 14; figures 1-11 page 10, line 20 -page 11, line 27 page 15, line 2-17 page 22, line 17 -page 23, line 23 page 24, line 1-17	1-3,7, 9-21
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 February 2001	02/03/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Van der Plas, J

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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